

Detection Thresholds of Falling Snow from Satellite-borne Active and Passive Sensors

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Precipitation, including rain and snow, is a critical part of the Earth's energy and hydrology cycles. In order to collect information on the complete global precipitation cycle and to understand the energy budget in terms of precipitation, uniform global estimates of both liquid and frozen precipitation must be collected. Active observations of falling snow are somewhat easier to estimate since the radar will detect the precipitation particles and one only needs to know surface temperature to determine if it is liquid rain or snow. The challenges of estimating falling snow from passive spaceborne observations still exist though progress is being made. While these challenges are still being addressed, knowledge of their impact on expected retrieval results is an important key for understanding falling snow retrieval estimations. Important information to assess falling snow retrievals includes knowing thresholds of detection for active and passive sensors, various sensor channel configurations, snow event system characteristics, snowflake particle assumptions, and surface types. For example, can a lake effect snow system with low (~ 2.5 km) cloud tops having an ice water content (IWC) at the surface of 0.25 g m^{-3} and dendrite snowflakes be detected? If this information is known, we can focus retrieval efforts on detectable storms and concentrate advances on achievable results. Here, the focus is to determine thresholds of detection for falling snow for various snow conditions over land and lake surfaces. The analysis relies on simulated Weather Research Forecasting (WRF) simulations of falling snow cases since simulations provide all the information to determine the measurements from space and the ground truth. Results are presented for active radar at Ku, Ka, and W-band and for passive radiometer channels from 10 to 183 GHz (Skofronick-Jackson, et al. submitted to IEEE TGRS, April 2012). The notable results show: (1) the W-Band radar has detection thresholds more than an order of magnitude lower than the future GPM sensors, (2) the cloud structure macrophysics influences the thresholds of detection for passive channels, (3) the snowflake microphysics plays a large role in the detection threshold for active and passive instruments, (4) with reasonable assumptions, the passive 166 GHz channel has detection threshold values comparable to the GPM DPR Ku and Ka band radars with $\sim 0.05 \text{ g m}^{-3}$ detected at the surface, or an $\sim 0.5\text{-}1 \text{ mm hr}^{-1}$ melted snow rate (equivalent to $0.5\text{-}2 \text{ cm hr}^{-1}$ solid fluffy snowflake rate).